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SOVIET REVIEW OF ZHEBROVSKIY'S BOOK ON ELECTRICAL PRECIPITATORS

/Comment: The following is the full text of a review of Elektrofil'try (Electrical Precipitators) by S. P. Zhebrovskiy, published by Gosenergoizdat, 1950, 254 pp./

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The Soviet Union is the only country in which a specialized literature on the electrical purification of gases is published regularly. This branch of engineering has experienced an extraordinary degree of development in the Soviet Union, where problems of corona discharge are studied intensively in scientific research laboratories, institutes, planning organizations, and institutes of higher learning.

This book is intended for engineers engaged in research on and operation of electrical precipitators, and also for specialists interested in corona discharge.

The book consists of an introduction, two parts with ten chapters, and appendixes. The introduction contains information on the importance of electrical purification of gases in industry. Further, it briefly explains the characteristics of particles suspended in gas, as well as the operating principle of electrical precipitators.

Part I, "Electric Discharge in Gases at Atmospheric Pressure," consists of five chapters. Chapter 1 describes the behavior of ions in gases. Chapter 2 explains corona discharges in gases. Chapter 3 contains the theory of the dc corona with a detailed solution of the Poisson equation, an analysis of Deutsch's theory, and derivations of basic formulas for determining the magnitude of current and corona in systems of two coaxial cylinders, and of single and multiple conductors between two planes. Chapter 4 deals with problems of spark discharges. Chapter 5 gives experimental volt-ampere characteristics for corona in gases containing no dust.

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Part II, "Practical Application of the Corona Discharge," also consists of five chapters (6 - 10). Chapter 6 examines the construction of electrical precipitators as used in the various branches of USSR industry. Chapter 7 is given to an analysis of the physical processes in the electrical precipitator. Chapter 8 discusses sources of power supply for electrical precipitators. Chapter 9 treats the operating characteristics, special design features, and typical forms of insulators for feeding high voltage into the precipitator. Chapter 10 deals with the separating properties of precipitators and the utilization of these properties in specialized equipment such as separators.

The appendixes contain a graphical analysis of plate-type electrical precipitators and a compilation of formulas for determining field intensity and corona current in systems.

Several chapters of the book are written on a rather poor level. A favorable impression is gained from the material in Part I which deals with the theoretical aspects. Certain problems of physics and engineering connected with the electrical purification of gases are examined with unexcelled thoroughness. Although the explanation of the physical aspects is sufficiently detailed, the analysis of important technological factors of the operation of electrical precipitators is too brief, particularly in regard to the composition and parameters of the gas, the degree of dispersion of the dust, the electrical conditions, etc.

One virtue of the book is its systematic presentation of material. The complex processes occurring in electric discharge in gases at atmospheric pressure are described in strict scientific language and interpreted mathematically. Final formulas are presented in a form suitable for practical use.

The book contains many graphs illustrating most of the mathematical and physical formulations. It supplies a great deal of experimental material supporting the theoretical calculations. The reader thus obtains a clear and complete view of the physics and engineering of electric discharge in gases at atmospheric pressure.

The favorable over-all impression produced by the book is lessened by the crude and occasionally obsolete material on the practical uses of corona discharge in Chapter 6 (Construction of Electrical Precipitators), and Chapter 8 (Power Supply). Chapters 6 and 8 describe the status of the problem under consideration during 1935 - 1940; however, they fail to reflect the experience and achievements of Soviet precipitator construction in the last decade, which was the most fruitful and characteristic period in the development of this branch of engineering.

In regard to the second part of the book: Chapter 6, as already stated, contains obsolete material on the building of electrical precipitators. For example, the author states that electric-power stations in the USSR use type DV and DVM honeycomb electrical precipitators for removing ashes from stack gases, and he describes their construction. He should have made it clear that these types were not installed in Soviet electric-power stations after 1940. More recently, power stations have been equipped with the more modern type DVP and DGP precipitators having electrodes in housings and uninterrupted agitation (rapper action) of the electrodes. These types were constructed by the "Gazoochistka" (Gas Purification) Trust. This is true also of the BTsE combination-type ash extractor described by the author. A number of these extractors were installed before the war in certain electric-power stations. At present, neither electrical precipitators nor battery dust extractors of this type are in use. More modern equipment has been developed.

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The author further asserts that three types of installations are used widely in metallurgical plants for electrical purification of blast-furnace gas, namely, dry single-stage purification, two-stage purification, and wet single-stage purification. He should have stated that only the wet single-stage equipment is found in USSR metallurgical plants; this type of equipment employs a process first developed in the Soviet Union and has proven most effective and economical. Late models of these precipitators using continuous washing of the electrodes have been installed in several plants (for example, the DM-156 scrubber-precipitator type).

The electrical precipitators used in sulfuric-acid concentrating installations are referred to in the book as "Chemico" equipments. Actually, the use of equipments obtained many years ago from "Chemico" (very outmoded and inefficient) was not widespread in our industry. Soviet specialists have developed more modern concentrating equipments which are several times more productive than the "Chemico" type for equal size. Accordingly, the precipitators for them differ considerably from the old K-56 precipitator described in the book.

In Chapter 7, the author deduces relationships for physical phenomena in electrical precipitators which hold true only for the ideal precipitator which is supplied strictly by direct current. For the actual precipitator fed by rectified current from a mechanical rectifier -- with its characteristic presence of transients caused by the making and breaking of the contacts -- the relationships given by the book may vary from the actual operating values. The characteristics of precipitators found in this chapter do not lend themselves to generalizations inasmuch as they are not representative of several types of precipitators, for example, electrical ash precipitators with continuous agitation.

The data in Chapter 8 on TU-200 and TU-335 electric installations provokes the following comment. These units were manufactured domestically until 1940. Later a type AF-18 unit was manufactured which differs from the earlier models in design improvements and in the switching circuit. The power-supply circuit shown in Figure 120 [not reproduced in this report] corresponds neither to the circuit of the older TU-200 (TU-335) unit nor to the newer AF-18.

In regard to voltage-regulating systems, the author's opinion is that the method which employs an autotransformer and commutator results in weakness of the unit, since commutators supposedly get out of order in a short time and, according to operating regulations, voltage regulation is not admissible at the time of breakdowns in the precipitator. Such a generalized opinion cannot be considered sufficiently well substantiated.

It is lamentable that Chapter 8 contains no mention of the widely-used three-phase power-supply units of electrical precipitators; a three-phase--two-phase power supply designed by A. M. Bamdas is described in the book, but this unit is not used in electrical gas-purification installations.

The physical hypotheses underlying the new impulse supply circuit suggested in paragraph 63 are debatable. The author believes that if one could increase the voltage in electrical precipitators for their given geometrical dimensions the result would be substantially increased efficiency because of the resulting higher current and stronger field. The author suggests that precipitators be supplied with impulse voltage without realizing that the impulse supply circuit would reduce the current and not increase it since the magnitude of the applied voltage is limited by the electrical strength of the precipitator and the latter is somewhat greater for impulse supply than for the usual full-wave rectifier supply.

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As a matter of fact, the field gradient, upon which the operating efficiency of the precipitator depends, is determined by the average value of the rectified current. The average value of the current, as is known, equals

$$I_{av} = \frac{1}{\sigma} \int_{\alpha}^{\alpha+\sigma} f(x)\,dx$$

This equation shows that the average value of the current will drop as the area bounded by the curve decreases. With impul supply, the average value of the current, given equal voltages, will be considerably less than with full-wave rectifier supply. An increase of the voltage on precipitators of more than 110-120 percent using impulse supply is impossible because the electrical strength of the precipitator would be exceeded.

The shortcomings noted, a majority of which might have been corrected by more careful editing, should be eliminated in any further editions of the book.

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